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ON UNILATERAL CONDUCTIVITY.*

By ARTHUR SCHUSTER, Ph.D.

While I was engaged in other work I discovered a new phenomenon in electricity which may conveniently be called "unilateral conductivity." My experiments show that in a circuit composed entirely of copper wires, joined together by means of binding screws, the electric conductivity in one direction may be different from what it is in the opposite direction. If a coil of wires be connected with the galvanometer, and a magnet rotates rapidly within the coil, currents in alternate directions will pass through the galvanometer.† Their effect, however, on the needle will counterbalance each other, and the needle will show no permanent deflection as long as the currents are equally strong. On the other hand, if the needle shows a permanent deflection, one current must be stronger than the other, and this again can only be caused by a difference in the conductivity, as the electromotive force acting in opposite directions must be equal. It is found that sometimes the currents induced by the rotating magnet have a very strong effect on the needle, and the effect shows best in wires which have not been used for a certain time. The most remarkable fact connected with unilateral conductivity is that a circuit of wires not showing unilateral conductivity may be made to conduct unilaterally merely by introducing, for a short time, a wire which shows the effect. When the wire is taken out again, the original circuit will show unilateral conductivity. The air condensed on the surface of the wire may possibly explain the phenomenon. Two wires screwed together may not touch each other, but be separated by a thin layer of air. A voltaic arc, the electrodes of which are of different form, will, as is known, show what I call unilateral conductivity, and a copper wire separated from the binding-screw by a thin layer of air will act somewhat like a voltaic arc. In order to test the theory, according to which all the facts mentioned above are easily explained, air was artificially condensed on the wire, by putting its ends for a certain time into powdered charcoal. A wire which showed no unilateral conductivity was thus made to show it, and after it had been destroyed again (which generally can be done by rubbing the wire, or screwing it to another binding-screw) unilateral conductivity was produced a second time by the same means. A third attempt, however, failed, and from that time all the means by which usually unilateral conductivity had been produced were not successful. If, therefore, the above theory is the correct explanation of unilateral conductivity, some unknown secondary cause (perhaps the diffusion of the gas into the wire) must be active, which at certain times prevents its being produced.

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* Read before the British Association, Belfast Meeting, Section A. Communicated by the Author.

† The small bar magnet employed was made to rotate very rapidly by attaching it to the axis of a siren.

ON THE NEW CONTACT THEORY OF THE GALVANIC CELL*

By J. A. FLEMING, B.Sc., F.C.S.

(Concluded from page 281).

The preceding quotations may be taken as affording the plainest notion of the new contact theory; and it will be seen that its fundamental propositions are briefly these:—

I. That two plates of different metals in one liquid are at the same potential when insulated and separated; *i.e.*, there is *no* difference of potential due to chemical affinity.

II. In a cell series the gradual rise in potential, or the electromotive force, is due only to the dissimilar metallic contacts.

III. The chemical action in the battery is the result rather than the cause of the difference of potential, and is looked upon as an accompanying action rather than as the actual creator of the current, it having little or no share in the production of the difference of potential between the terminals.

These are, I venture to think, points not to be admitted as proved without further inquiry, and against which, as I shall hope to show, some grave if not insuperable objections may be urged, founded on other experimental evidence. The first question to be settled is, then, whether in a series of cells the *whole* of the difference of potential between the terminals is due to the contacts, as above stated, or whether *any* portion is due to the tendency towards chemical combination existing between the metals and the electrolytes; and, as a consequence, whether in a single cell the plates are at the same potential or at different potentials, owing to the difference of chemical action upon them. Now I think this point will be sufficiently proved if we can establish by experiment—(1), that a battery of cells can be constructed without any dissimilar metallic contacts and with terminal plates of the same metal, and which shall yet exhibit difference of potential and continuous current; for if this is possible, it must follow that chemical affinity *alone* is capable of *creating* electromotive force as well as of maintaining a current, and that, in an ordinary cell-series, *some* part at least of the electromotive force is due to this cause, whilst the remainder is the result of the metallic contacts that may exist. Or (2), if we can establish directly that the two plates in one cell are not at the same potential, as stated by more than one authority.

With regard to the first point, it will be remembered that an old experiment of Faraday's proved that a current can be maintained and decomposition effected by a single cell where there is no dissimilar contact. It is not easy to see how this experiment can be explained by any form of contact theory; indeed it appears unanswerable. But in order to leave no point unsettled by experiment, it seemed desirable to try and arrange a series of cells in which all dissimilar contact was absent, so that the difference of potential due to chemical action might be separated from that due to the contacts and rendered visible by the electroscope. It is obvious that we can make no attempt to do this unless we can in some way or other obtain a battery with terminals of the same metals; for otherwise the very junctions with the electroscope introduce what we want to eliminate, viz., dissimilar metallic contact. But the following is a method by which this can be accomplished:—If plates of lead and copper be placed in nitric acid, the lead is positive to the copper, since it is most acted upon; but if lead and copper be placed in solutions of alkaline persulphides, then the copper is most readily acted upon, and is positive to the lead,—that is, the positions are reversed.

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* Read before the Physical Society, March 21 1874.

Now, if we place in a cell dilute nitric acid and a copper and a lead plate, we cannot join up another cell of the same sort in series without introducing contact. But if, instead of using a cell containing acid, we take another cell containing sodic pentasulphide, and bend over the lead plate of the first cell to dip into the liquid in the second cell, and place therein also a copper plate, we shall then have two cells joined up in series without dissimilar contact and with similar metals for terminals; and yet the action of the liquids on the metals is such that in the one the lead is positive to the copper, and in the other the copper is positive to the lead. Hence there is a regular rise in potential in passing through the two cells, and on joining the terminals by a copper wire a current flows through both cells in the same direction. It is obvious that we need not limit ourselves to two cells. By forming a pile of alternate cells filled with acid and alkaline persulphide, connected by bent copper and lead plates alternately, we shall be able to accumulate difference of potential to any extent; and if the number of acid and alkaline cells be equal, we shall always end with a plate similar to that with which we began. Such a battery will exhibit a difference of potential between its two terminals when the circuit is opened, and will give a current when it is closed. In it we have nothing but chemical action to rely upon, both for creating electromotive force and for maintaining the current, We have no dissimilar contacts; and as the terminal plates are similar, we can effect the junctions with the electroscope without introducing an unbalanced dissimilar contact. I have constructed such a battery of sixty cells; and by the kindness of Prof. Guthrie, to whom my thanks are due, I have been permitted to compare its potential with that of a Daniell's cell, by means of a quadrant electrometer belonging to his laboratory. By this means it is at once seen that the difference of potential increases proportionally to the number of cells, the electromotive force of four cells being about equal to that of one Daniell. Joined up with a galvanometer it indicates a current, which, however, rapidly falls off in strength, owing to the formation of an insoluble cupric sulphide upon the copper plates. Joined up in opposition to a single Daniell's cell, with a galvanometer included in the circuit, I find that it requires from four to five cells to balance the force of the Daniell at first immersion; but after leaving it to work on short circuit for two and a half hours its electromotive force had fallen off 50 per cent; it then required about eight cells to bring the needle to zero. This gives for the electromotive force of two cells at first about 0·5 of a volt; or the whole sixty cells are equal nearly to fifteen Daniell's cells. It readily effects the decomposition of many electrolytes, and exhibits therefore every property of an ordinary cell-series. Above all, it will be noticed that since there is a regular rise in potential in passing from cell to cell, and as all parts of each plate must be at the same potential, that rise can only take place at the surfaces where the active metals are in contact with the electrolyte (that is, at the seat of the chemical action), and that therefore two metals in one electrolyte *cannot* be at exactly the same potential. But I find that more direct evidence still of this fact is to be found in an experiment of Faraday's, which seems to have escaped the notice of the contact theorists.

In his "Experimental Researches" he gives the following fact:—"I took a voltaic apparatus, consisting of a single pair of large plates, namely, a cylinder of amalgamated zinc and a double cylinder of copper. These were put into a jar containing dilute sulphuric acid, and could at pleasure be placed in metallic communication by a copper wire connecting the two plates. Being thus arranged, there was no chemical action whilst the plates were not connected; on *making* the contact a spark was obtained. In this case it is evident that the first spark must have occurred before metallic contact was made, for it passed through an interval of air; and also that it must have tended to pass before the electrolytic action began, for the latter could not take place until the current passed, and the current could not pass before the spark appeared." "Hence," he says, "I think there is sufficient proof that the zinc and water were in a state of powerful *tension* previous to the actual contact." It is difficult to reconcile this with the experiment of the half discs and drop of water made by Sir W. Thomson. But, at any rate, a consideration of the whole of the facts would seem to point out that the only safe conclusion is, that in any series of cells, of any sort, the electromotive force is a complex effect, being due to the algebraical sum of all the differences of potential due to dissimilar contacts *plus* the algebraical sum of the differences of potential due to the chemical affinities of the metals and electrolytes *minus* any opposing force due to polarisation, &c.; and that, so far from being the exclusive cause, the contacts can only be said strictly to have a share in producing the difference of potentials between the extremities of a battery. And, lastly, we may with advantage compare the statements of the contact theory with certain other well-ascertained facts. Such statements, for instance, as these:—"If we close the circuit by connecting the metals by a wire, we then have constant separation of electricities at the point of contact of different metals, and constant re-combination attended with decomposition through the electrolyte." "The electricities separated at the metallic junctions recombine through the water," "whilst the current flows the water is decomposed,"—which seem based on the assumption that the principal seat of the electrical actions is *not* to be looked for at the seat of the chemical actions. But, now, how does this fit in with those cases of electro-chemical inversions noticed by De la Rive, where the direction of the current in a cell is *reversed* by simply diluting the electrolyte? Thus zinc is negative to tin in strong nitric acid, and mercury negative to lead; but in weak nitric acid the positions are reversed. Hence, if couples be formed of these metals in strong nitric acid, and the acid be gradually diluted, the current first ceases, and then is reversed in direction.

Here, without altering the metallic junctions, we can at pleasure alter the direction of the current, and therefore, also, the direction of the fall in potential, since the current must flow from high to low potential. This seems conclusive that the chemical electromotive force must be even greater than the contact electromotive force. This reversal of the current, by changing the seat of the chemical activity, may be shown in another way, depending on the application of a very old principle. If plates of copper and clean iron be connected by copper wires with a galvanometer, and the iron rendered passive by immersion for a moment in strong nitric acid, then if these plates are plunged into dilute nitric acid the galvanometer indicates a strong current going through the cell from the copper to the iron. If they be removed for an instant, and the iron plate touched, on again immersing the current is found to be reversed. Or we may again change the conditions, and notice that it is not sufficient to have merely two different metals and an electrolyte to form a cell. If plates of pure gold and platinum be placed in nitric acid, the most delicate galvanometer detects no current, and the same for many other pairs of metals and electrolytes.

Here we have contact of different metals producing its difference of potential; yet no current flows round "decomposing the electrolyte," as, according to the contact theory, it should do; but the instant we give play to chemical combination the ordinary results ensue. If the extremities of the copper wires from a galvanometer be attached to iron plates, and these plunged into separate cups of dilute nitric acid, on making connection between the two cups—by a bent iron plate dipping into each—no current is detected. On making one limb of the connecting plate passive, and re-immersing, a strong current is visible; and we find that we have the direction of the current completely under command by making any of the four plates more or less acted on than the other three.

If these experiments are to have any importance attached to them, it can scarcely be doubted that they land us in conclusions similar to the others,—namely, that we must look for the principal source of the electrical disturbances at that place where the greatest chemical activity is being brought into play; and that whereas contact of metals is in itself productive of definite electrical separation, there is in the battery another cause assisting in the production of difference of electrical potential between the terminals, viz., the potential chemical combination between the metals and electrolytes existing when the circuit is open,—the energy of the current produced when the circuit is closed being, of course, the equivalent of this potential energy which disappears.

ELECTRO-DEPOSITION OF METALS.

By J. T. SPRAGUE.

(Continued from page 265.)

Resistance is the general term which includes every property of matter and every form of work which tends to prevent electricity from moving, or absorbs the energy of the electromotive force. Every substance has its own *specific* resistance or conductivity; every kind of work its definite mechanical equivalent. But resistance is twofold. (1). Resistance proper—such as that of wires, of liquids at a distance from the electrodes, of heat produced, of energy absorbed in chemical work, and of mechanical effects. These all obey the formula $R = \frac{E}{C}$, whether these be great or small; for instance, a piece of wire will measure the same resistance whether 1 cell or 100 are passing current through it, and whether that current be 0·1 veber or 100 vebers, allowing, of course, for the effect of the heat produced. (2). If a weak cell is opposed to a stronger, or if chemical work is being done which sets free radicals having a mutual affinity or alters the constitution of the liquid, an effect is produced which may be balanced by or measured as a resistance,—but this will not obey the formula; it will be different in value with a strong and a weak current, and will fluctuate with various conditions: this is not true resistance; it is a *counter electromotive force;* express it as such as e, and then the remaining resistances will agree with the formula $\frac{E-e}{C} = R$.

True resistance in conducting bodies increases as the length of the conductor and diminishes as its sectional area, so that the specific resistance of any unit measure of bulk being known (as the unit grain wire, suggested p. 199), the actual resistance of any bulk may be calculated. In liquids this resistance will vary as the area of the plates, provided the plates fill a cross section of the vessel. There is another element of resistance which is not readily measurable, and may vary with the current: this is due to the adhesion or contact at the two surfaces of metal and liquid, and the variation will be caused —whenever a gas is given off—by altering the actual area of the surfaces in contact. A counter electromotive force is also set up always when a gas is given off, when an acid and alkaline radical is set free, and to some degree in ordinary operations which tend to produce a solution charged with metal at the anode and deficient in metal at the cathode: this occurs because in all such solutions, besides the metallic salt, there is a solvent employed which is usually the actual carrier of the current.

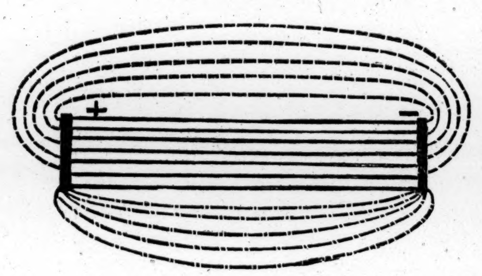
The current divides itself among all the paths open to it in the ratios of the several resistances, and when there are two or more paths open these are called "derived circuits." But every conductor is really a system of derived circuits, for a single molecular chain is the unit circuit; so in wires the resistance diminishes as the area increases, because the number of molecular chains or "derived circuits" increases as the area of the section increases. But this is not the case in liquids.

It might be supposed that the current passes direct from plate to plate, affecting only the included liquid: this would be the case if it chose the shortest path, or least resistance, as it is often erroneously said to do in the case of lightning; if this were so, the resistance of liquids would decrease in the ratio of the increased area of plates immersed. But what really takes place is shown in the figure. The current divides itself in every direction, even the backs of the plates being active and the action at each part of the plate is proportional to the lengths of the various paths open to it to all parts of the opposed plate.

If a strip of ebonite have plates of metal secured on its edges, connected to wires and a galvanometer, when dipped in the liquid it will carry off a portion of current having a relation to the resistance of the length of liquid the ebonite displaces, and this being in all cases the same such a system will really carry off current proportional to that passing in the part of the vessel in which it is placed. By such means it is found that every particle of liquid in the vessel is polarised and forms part of the circuit, and for this reason it is that a pair of plates cannot form a circuit in the liquid, but require an external conductor. Any piece of metal suspended in a liquid undergoing electrolysis acts like such a system; it forms a conductor, and one end will be dissolved, and the other end deposited upon—although it is in no way connected to—a battery: this will therefore happen to any unconnected object left hanging in a depositing solution, or which may accidentally fall off its connecting wire.

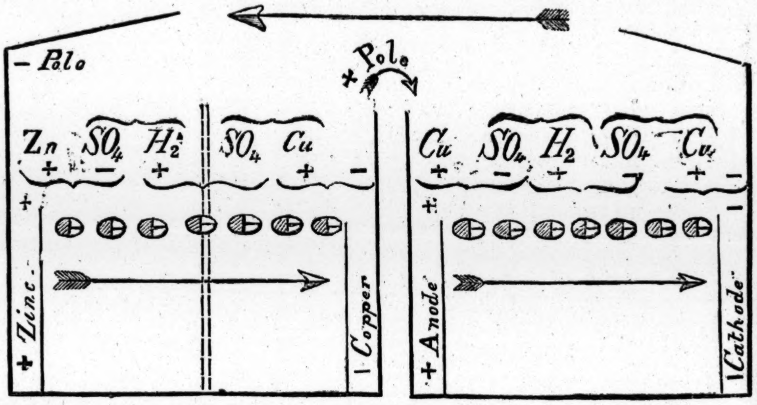
We should therefore regard a vessel containing solutions as composed of a series of derived circuits of *unequal resistance;* we should also regard objects and plates as the points of origin of such derived circuits, and take proper precautions to equalise them. The figure will show how it is that projecting portions, and especially edges, collect a heavy deposit; the principle is exactly the same as that of points in frictional electricity,—a larger number of lines of polarisation can originate there, in all directions, than upon flat parts; therefore the total ressistance of an equal area is less there, and as a consequence the action is to that extent greater.

FIG. 1.



The name *electrolysis* is given to the process of transmission of electricity through liquid substances (in solution or fused), when accompanied with a breaking up of the substances and setting free their constituents. There is some doubt whether electricity can ever pass through liquids without effecting such a decomposition, although it is certain that small currents do so pass without effecting any apparent decomposition. For instance, there is good reason to believe that water is not an electrolyte at all, and that perfectly pure water is a highly insulating substance. But perfectly pure water has probably never yet existed, and if obtained would remain pure only a few minutes, and not an instant if current were attempted to be passed. Water, if exposed, always contains air also, richer in oxygen than common air; it is therefore easy to conceive that the small current which does pass is effected by means of this air entering molecules of water at one pole and leaving them at the other, just as copper does in an ordinary coppering solution. The latest published experiments on this subject are by Favre, who set up a voltameter saturated with gases, connected to a Smee and a Daniell cell: no sign of gas was shown in the voltameter, yet the Smee in twenty-four hours gave off 20 c.c. of hydrogen, and equivalent copper was deposited in the Daniell, thus measuring the current which had actually passed without producing chemical action in the voltameter; but a voltameter so saturated always contains dissolved oxygen, and even peroxide of hydrogen, and this was probably the actual carrier of the current. It is, however, probable enough that water and other liquids have a specific conductivity quite independent of electrolysis, as gutta-percha has.

FIG. 2.



It is necessary to clearly understand the terms employed in this particular branch of electricity. Each vessel containing liquid in a galvanic circuit may be called *a cell:* these are of two orders:—(1), cells in which energy is produced, electromotive cells—these form the battery; (2), cells in which energy is absorbed, decomposition cells. Notwithstanding this distinction the action which takes place in all depends on the same principles, and all offer a resistance to the passage of current identical in laws and character to that offered by wires. In each cell there are two plates or poles. In the battery cells the zinc is the + or positive metal, and originates the action which passes through the liquid to the – or negative *plate.* But the wires from these plates take reversed names as *poles,* because they carry the current in the reverse direction externally. Hence the wire from the zinc or + positive *plate* is the – or negative external *pole,* while that from the – *plate in* the battery is the + or positive *pole of* the battery. These wires (or more strictly the plates attached to them) or *poles* are called *electrodes:* the + or positive electrode is called the *anode,* and the – or negative electrode is called the *cathode.* The anode in the decomposition cell represents the zinc in the battery cell; lik the zinc it is + to the liquid, and gives up energy to the liquid (though that energy is derived from the current itself in this cell): like the zinc it dissolves if made of materials which can combine with the negative or – radical of the solution; therefore in electro-metallurgy it is usually made of the metal to be deposited, and dissolves away in exactly the same equivalent rate as the zinc of the generating cell does. The following diagram illustrates this in the action of a Daniell cell and a coppering cell. This shows the polarisation set up in the complete circuit from the zinc in the liquid, with equivalent actions resulting in both cells, the upper brackets showing the original arrangement of liquids, the lower ones the effect of the action. At the + plates to the left in each cell, zinc in the battery, the anode in the decomposition cell, an atom of metal is removed from the plate; the intervening molecules transmit the action, absorb the released atom originally united to the first acid radical, and at the end of the chain in each cell—in contact with the negative plate or cathode—a positive radical; in this case copper in both cells is set free. This diagram is arranged to furnish several illustrations of the laws of electrolysis.

The description given of molecules (p. 135) especially applies to the conditions of electrolysis: they consist of two radicals capable of acting as + and −, and so giving a polarity to molecules resembling that of a row of magnets movable on their centres. The molecules are typified by the rows of ellipses in the diagram, and chemically by the symbols H_2SO_4, $CuSO_4$, in which each symbol (or group, such as H_2 or SO_4, forming a compound atom or radical) represents a half molecule or radical: these radicals, single or compound atoms, are called *ions*. Those ions which in electrolysis turn towards the anode are called *anions*; they are the electro-negative, chlorous, or acid radicals of which oxygen may be taken as type: those which turn to the cathode are called *cations*; they are the electro-positive basylous, basic, and metallic radicals, of which hydrogen may be taken as type. These terms were introduced by Faraday, and the generally accepted laws of electrolysis are based upon his work. For convenience sake I give these laws as formulated by Miller; but increased knowledge of the facts and laws of chemistry has introduced great modifications, which will be explained, as they greatly affect the meaning of these laws:—

I. No elementary substance can be an electrolyte.

II. Electrolysis occurs only while the body is in the liquid state.

III. During electrolysis the components of the electrolyte are resolved into two groups: one group takes a definite direction towards one of the electrodes; the other group takes a course towards the other [illegible]. (Faraday held that only salts containing one equivalent of each of two substances forming the compound would act as an electrolyte, but this idea is now superseded by a more general conception).

electrode/

IV. The amount as well as the direction of electrolysis is definite, and is dependent upon the degree of action in the battery, being directly proportionate to the quantity of elecricity in circulation.

V. Those bodies only are electrolytes which are composed of a conductor and a non-conductor.

Of these laws, V. (added by Miller) is only a vague and general conception, while III.—covering all the ground of electrolysis—requires examining under several divisions, and IV. requires a definition of the meaning of "quantity of electricity in circulation."

Berzelius's electro-chemical theory, which long ruled chemistry, assumed that each element possessed, as part of its constitution, a definite quantity of positive or negative electricity, which set up the chemical attractions between them; that they united into acid and basic radicals, the attractions of which for each other were due to the excess of + or − electricity not neutralised in the primary act of combination: he therefore drew up a list of electro-negative and electro-positive substances. It will be seen, therefore, that on this view each kind of molecule possessed *different quantities of electricity*, which are the causes of the varying degrees of affinity. But Faraday distinctly proved that there is a relation based upon the equivalent constitution of matter. Thus if a cell is set up, based upon zinc displacing silver from its nitrate, a definite quantitative result will be effected by the current; if passed into a copper solution it will reduce a definite quantity of copper, and the quantity will be in the ratio of the old equivalents of the metals,—*i.e.*, for 108 grains of silver precipitated in the battery, 31·75 will be deposited in the cell. But copper will precipitate silver, though with much less force than zinc does,—therefore it is said that a much lower affinity is at work; if, then, copper is used for a battery with a silver salt, a current will be produced, set up, and this current also will, for the 108 grains of silver in the battery, deposit 31·75 of copper in the cell. Again, iron will throw down the copper, and zinc the iron; in each case a lower affinity at work in the battery produces exactly equal reduction in the cell, though taking different times to effect it. But, again, if we place in a series cells containing different classes of molecules, and pass a current through all,—such as silver, copper, and iron,—the same current passes through them, and deposits in each cell its metal in the order of its equivalent, 108 silver, 31·75 copper, 28 iron, for each 32·6 of zinc dissolved in a cell of the battery. Therefore Faraday said that every molecule, no matter what its nature or what the chemical affinity within it, requires or gives up the *same quantity of electricity*, and this is law IV.

How shall we reconcile these two conflicting views, for both of them are based on truths? Easily—when we get clear, first, of the fluid theories of electricity. When we see that electricity is a something wholly dependent on the molecular constitution of matter, that it can be transmitted or measured only by motions of the molecules, and those motions transmitted along a definite chain by the action of one molecule upon another, it is easy to see that there must be a relation dependent upon the *number* of molecules moved or broken up, which relation we may, if we please, call a *quantity* or an *equivalent* of electricity, and so take possession of Faraday's labours.

When we learn that energy is an integral part of the molecules of matter,—that the component atoms are moving at definite rates, as the spectroscope shows,—and that chemical combination is attended with a reduction of that motion, and its release as external heat, or as motion along a line of polarised molecules in electricity,—we see why each such action must give up a definite amount of energy, and why, according to its amount, the molecular motion it sets up (the "quantity") shall be slow or rapid, and therefore the tension set up upon the molecular chain shall be great or small in the ratio of the chemical affinities at work. Here, then, we take possession of Berzelius's labours, and connect the two conflicting theories.

DUPLEX AND QUADRUPLE TELEGRAPHY.

By ARTHUR R. GRANVILLE.

WITHOUT a question the Americans are maintaining their ground for ingenuity and enterprise in the electrical world, by turning their attention to telegraphic inventions. Although the practicability of duplex telegraphy was known as a scientific curiosity quite twenty years ago, it was far in advance of its age, and could not be put to any use by reason of certain difficulties,—insuperable according to the then known laws of electricity,—so that the invention lay fallow for that period. A further reason for the invention not being followed up may be found in the fact that the traffic of those days was easily met, and telegraph engineers were not goaded on to investigate the difficulties attending the introduction of a system which—by enabling lines to perform twice their previous amount of work—has virtually doubled the efficiency of wires in use.

To an American, Mr. Stearns, belongs every credit for dispersing those difficulties by a happy use of the condenser. Though not the inventor of the system,—the honour of invention belonging to Dr. Gintl, of Vienna, and W. H. Preece, of Southampton, Messrs. Siemens, Halske, and Frischen, of Berlin,—yet to him belongs the highest praise for having resuscitated an old laboratory experiment; for having nursed and trained it from infancy to maturity; and for introducing it to the practical world, as a valuable system requiring but slight additions to the instruments in use amongst telegraphers to render it ready for immediate practice. And so successful has the working of the "duplex" proved that in a little over two years it has established itself as a great and most profitable system, and may be regarded as indisputably one of the most important turning-points in the history of telegraphy and electrical science. It is reckoned equal in importance to the discovery of Steinheil, who demonstrated that return wires could be dispensed with by the use of earth plates. In resultant effects the "duplex" is strikingly similar to Steinheil's discovery, since both have doubled the resources of telegraphy; the former *directly*, by actually doubling the working capacity of wires; the latter by halving the lengths of lines, inasmuch as return wires were proved to be no longer needed.

The benefits arising from the "duplex" system bid fair to be multiplied still further by the joint labours of two Americans, Messrs. George B. Prescott and Thomas A. Edison, who announce the perfecting of what they designate "The Quadruple System." This system is described as a "*new* process of multiple transmission, by which two messages can be sent simultaneously in the same direction over the same wire, and either message can be dropped at any way station on the circuit." The "duplex" system can also be applied to this "multiple" system, so that *four* messages may be despatched together over the same wire in the same direction. The recommendations in favour of the "quadruple" are that, like its predecessor, the old Morse key can be used, and the only expense attending its introduction is the purchase of additional parts of machinery; there is no sweeping away of old appliances and substitution of new ones. The Western Union Telegraph Company, of which Mr. Prescott is electrician, is about to try this system,—in fact, put it into practice on all their lines,—so that we shall shortly learn with what success the system is capable of being worked. Of this we may be certain, that should failure threaten the system Messrs. Prescott and Edison will not spare strenuous efforts to overcome whatever difficulties may present themselves.

How this "quadruple" result is obtained has not yet been explained, but the method is not difficult to conjecture. After the "duplex" had been perfected by Messrs. Gintl, Siemens, Halske, and Frischen, other physicists endeavoured to find a method of exceeding even that, and the result of their researches was that, in 1855, Stark, of Vienna, proved two messages could be sent along a single wire in the same direction. His plan was to launch, by two keys, two currents of different potentials into the wire, to act upon two relays at the receiving station. These relays were arranged so that when the weaker current alone traversed the circuit only one relay was acted upon; when the stronger current traversed the line the other relay was worked; when both currents were in circuit, then both relays were set in action. How the arrangement was effected may be seen in Mr. Sabine's "History and Progress of Telegraphy," and it is no doubt this arrangement—perfected by the aid of modern experience gained in working the duplex system—which is about to be adopted in the offices of the Western Union Telegraph Company. Should this system succeed, there surely seems to be no reason why the number of messages capable of being transmitted along a given wire should not be still more increased by the addition of further appliances and the removal of difficulties, which—from experience gained in working the "duplex" and "quadruple" systems—may be even anticipated. Whatever, indeed, should be the ultimate perfection of the multiple system, whether by English enterprise or not, the chief honour belongs to the Americans for being the first *adapters* who cleared the way and acted as pioneers.

The Transmission of Music by Electricity.—Mr. Elisha Gray, of Chicago, has patented a means of transmitting sounds and music through a wire by electricity. That gentleman is well known as an inventor and manufacturer of telegraph instruments, and his new instrument—which he calls a "telephone"—has been tried, with the most satisfactory results, over a circuit of 2400 miles of the Western Union Telegraph Company's wires. A lengthy description has appeared in some of the American papers, of so glowing a character as apparently to be somewhat exaggerated. That such things are possible is well known, since instruments of a similar nature have already been invented in Europe, but have never attained the perfection said to have been reached by the "telephone." The writer of an article in a prominent American paper describes it as the first step toward doing away with manipulating instruments altogether, and that he believes in time operators will transmit the sound of their own voices over the wires,—an end apparently impossible to attain, however much desired.

"The transmitting apparatus consists of a key-board having a number of electro-magnets corresponding with the number of keys on the board, to which are attached vibrating tongues or reeds, tuned to a musical scale. Any one of these tongues can be separately set in motion by depressing the key corresponding to it. Thus a tune may be played by manipulating the keys in the same way as those of an ordinary piano or melodeon. To this transmitting instrument the conducting wire is attached, the other end being attached to the receiving apparatus, which may be anything that is sonorous so long as it is in some degree a conductor of electricity. A violin with a thin strip of metal stretched between the strings at a point where the bridge of the instrument is ordinarily placed, will, on receiving the sound transmitted through the conducting wire from the piano, give out a tone very similar in quality to that of a violin. If then the metallic strip is electrically connected with a wire, say 500 or 1000 miles long, which has its distant end properly connected with the transmitting instrument, any one at the receiving end can distinctly hear, without the aid of electro-magnetism, the tune or air which is being played 500 or 1000 miles away from him, if he properly manipulate the receiving apparatus. The quality or *timbre* of the tones depends upon the character of the receiving apparatus, which may be a violin prepared as described above, a tin hoop, with foil paper heads stretched over it, after the fashion of a baby's rattle, a nickel five-cent piece, an old oyster-can, and a thousand other things. A sound made by interrupting, with the common telegraphic key, has become, under favourable circumstances, at the receiving end of the wire one sustained note without any more scientific sounding apparatus than that of a piece of common tissue paper."

This description is vague in many of the most important points; for instance, the mode of connecting up the instruments, both at the despatching and receiving ends, and in what manner the current at the receiving station sounds the note emitted at the sending station. An electrical sound-transmitting instrument, also called a telephone, was designed by a Dr. Van der Weyde, some five or six years ago, and was the result of a thorough study of the laws of electro-magnetism, founded on the fact that the difference in pitch of different tones is caused by different velocities of vibration of the elastic sounding bodies. Now it was then proved that *no quality* of tone could be transmitted, nor could articulate words be despatched, and it is difficult to understand how the high predictions entertained of Mr. Gray's machine in this respect can be carried out. It is true the instrument invented by Dr. Van der Weyde was simply an elongated wooden box, to which were attached wires (rendered magnetic by electric currents passing around them, so as to slightly elongate them), and that these wires produced sounds by vibrating under the influence of electric charges corresponding in number to the wave vibrations of the sounds originally despatched. The telephone invented by Mr. Gray appears to depend on a different principle, for it plays on violins and various other objects. Still it is advisable to hesitate accepting the great advantages promised, inasmuch as equally great results were prophesied respecting Dr. Van der Weyde's apparatus, which clearly never could and never have been realised.

The invention of a telephone is of no practical use to the commercial world, and at best can only be regarded as a novel scientific feat serving to illustrate lectures. It is, however, very encouraging to note that the Americans are turning their attention to these subjects; and their success shows that, if British electricians wish to keep ahead in the electrical and telegraphic field, they must apply themselves to the study of questions not only of pure practice, but also of abstract electrical science, in the desire to elucidate more of the laws regarding electricity, without a thorough knowledge of which it is impossible to overcome the difficulties attending the introduction of systems known only in the philosopher's laboratory, and which undoubtedly, in many cases, require but patient investigation to render of commercial utility.

Notices of Books.

Kurzer Abriss der Geschichte der Elektrishen Telegraphie. Von Dr. K. E. Zetzsche. Berlin: Julius Springer.

This work is a compact sketch of the history of electric telegraphy, drawn up with especial reference to the historical telegraphic exhibition of the German empire, as displayed at Vienna in 1873. We find an account of the earliest telegraphic experiments with frictional electricity, due to Marshall, Reusser, Böckmann, Lomond, &c., and extending from 1753 to 1816. None of these attempts were successful, though the suggestions of Sir C. Ronalds were not without merit. Galvanism was first applied to telegraphy in 1809, by Sömmering, whose apparatus—depending on the decomposition of water by the current—is figured and described here. This instrument, though capable of use, never came into practical application, no more than did the proposal of Coxe, depending upon the decomposing action of the current upon metallic salts. The discovery of electro-magnetism by Oerstedt gave a new direction to telegraphic experiments. Ampère and Fechner proposed contrivances. Schilling exhibited an improved telegraph in Bonn and Frankfurt, in 1835. Here it was seen by Muncke, who is supposed to have drawn the attention of Cooke to this novel application of electricity in 1836. The first telegraph on a large scale was constructed by Gauss and Weber, at Gottingen, in 1833. It was 3000 feet in length, and remained in use till 1838.

The author next describes the telegraphs of Steinheil, the successive improvements of Cooke and Wheatstone, of Siemens, Halske, Kramer, and Stöhrer, as also those of Schäfler, Bauer, and Kreb. The various accessory apparatus—such as galvanoscopes, lightning-conductors, rheostats—exhibited at Vienna are described.

The sources of electricity exhibited, and the apparatus for putting up telegraphic lines and for military telegraphy, complete the work, which is, throughout, copiously illustrated.

The steamers *Faraday* and *Ambassador*, having on board the Ireland-Newfoundland section of the cable of the Direct United States Cable Company, for which Messrs. Siemens Brothers are the contractors, left Gravesend on the 26th ult. for Ireland to proceed with the laying of the cable. At Ireland they will join the steamer *Dacia*, which vessel completed the laying of the Irish shore end of the said cable on the 21st ult.

BRITISH ASSOCIATION
FOR THE
ADVANCEMENT OF SCIENCE.

Belfast Meeting, August 19, 1874.

President.—Prof. Tyndall, F.R.S., D.C.L., LL.D.

The following is a list of the papers on electrical subjects read before Section A (Mathematical and Physical Science), under the presidency of the Rev. Prof. J. H. Jellett, M.A., M.R.I.A.:—

Prof. G. C. Foster.—Suggestions for a Re-determination of the Absolute Electro-Magnetic Units of Resistance, and Electromotive Force.

W. Symons.—A New Method of Constructing Carbon Cells and Plates for Galvanic Batteries.

W. Symons.—A Cheap and Convenient Galvanic Battery adapted for Weak but Continuous Currents.

Prof. W. F. Barrett.—Report of the Committee on the Molecular Changes accompanying Magnetisation.

Dr. Feddersen.—On some Peculiarities in the Electric Discharge from a Leyden Jar.

Prof. Clerk-Maxwell.—On a Solution of a Problem in Statics by Kirchhoff's Equations of Electric Currents.

Robert H. Scott.—On the Importance of Improved Methods of Registration of Winds on the Coast, with a Notice of an Anemometer designed by Mr. W. De la Rue to furnish Telegraphic Information of the Occurrence of Strong Winds.

Prof. G. C. Foster.—Report on the Teaching of Physics.

Prof. W. F. Barrett.—On the Teaching of Practical Physics.

Arthur Schuster.—On Unilateral Conductivity.

Prof. G. C. Foster.—Geometrical Illustrations of Ohm's Law.

Arthur Schuster.—On Ohm's Law.

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Section G (Mechanical Science).

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We abstract the following from Prof. Thomson's Address to the Mechanical Section:—

In Railway Engineering, one of the most important topics for consideration, as it appears to me, is that which relates to the abatement of dangers in the conducting of the traffic.

Gradually, during a period of twenty or thirty years past, a very fine system of watching, signalling, and otherwise arranging for the safety of trains, has been contrived, and very generally introduced along our principal lines of railway. In saying this, I allude chiefly to the block system of working railways, with the aid of telegraphic signals and interlocking mechanisms for the working of the points and signals.

In former times it was customary to allow a certain number of minutes to elapse after a train passed any station, or junction, or level crossing, or other point where a servant of the company was stationed, before the succeeding train was allowed to pass the same place. Thus at numerous points along the line a time interval was preserved between successive trains. It was quite possible, however, that the foremost of the two trains, after passing any of these places where signals were given, might become disabled, or might otherwise be made to go slowly, and that the following train might overtake it, and come into violent collision with it from behind. In order to provide against the occurrence of such accidents a system was introduced called the *Block System;* and its main principle consists in dividing the line into suitable lengths, each of which is called a *block section,* and allowing no engine or train to enter a block section until the previous engine or train has quitted that portion of the line. In this way a space interval of at least the length of a block section is preserved between the two trains at the moment of the later train's passing each place for signalling; and the risk of this space interval becoming dangerously small by negligence or other accidental circumstances, as the latter train appoaches the next place for signalling, is almost entirely avoided.

Further, at each signalling station, the various levers or handles for working the points, and those for working the semaphore signals for guiding the engine-drivers, instead of being—as was formerly the case—scattered about in various situations adjacent to the signalling station, and worked often some by one man and some by another, without sufficient mutual understanding and without due harmony of action, are now usually all brought together into one apartment called the signal-cabin. This cabin, like a watch-tower, is usually elevated considerably above the ground, and is formed with ample windows or glass sides, so as to afford good views of the railway to the man who works the levers for the semaphores and points, and who transmits by electricity signals to the next cabins on both sides of his own, and, when necessary, to other stations along the line of railway.

The interlocking of the mechanisms for working the points and for working the semaphores, which, by the signals they show, control the engine-drivers, consists in having the levers by which the pointsman works these points and signals so connected that the man in charge cannot, or scarcely can, put one into a position that would endanger a train without his having previously the necessary danger-signal or signals standing so as to warn the engine-driver against approaching too near to the place of danger.

The latest important step in the development and application of the block system is one which has just now been made in Scotland, on the Caledonian Railway. Before explaining its principle, I have first to mention that a semaphore arm raised to the horizontal position is the established danger-signal, or signal for debarring an engine-driver from going past the place where the signal is given. Now the ordinary practice has been, and still is, to keep the semaphore arm down from that level position, and so to leave the line open for trains to pass, except when the line is blocked by a train or other source of danger, on the block section in front of that semaphore, and only to raise the semaphore arm exceptionally as a signal of danger in front. The new change, or improvement, now made on the Caledonian Railway consists mainly in arranging that along a line of railway the semaphore arms are to be regularly and ordinarily kept up in the horizontal position for prohibiting the passage of any train, and that each is only to be put down when an approaching train is—by an electric signal from the cabin behind —announced to the man in charge of that semaphore as having entered on the block section behind, and when, further, that man has—by an electrical signal sent forward to the next cabin in advance—inquired whether the section in advance of his own cabin is clear, and has received in return an electrical signal meaning "*The line is clear; you may put down your debarring signal, and let the train pass your cabin.*" The main effect of this is, that along a line of railway the signals are to be regularly and ordinarily standing up in the debarring position against allowing any train to pass; but that just as each train approaches, and usually before it has come in sight, they go down almost as if by magic, and so open the way in front of the train, if the line is ascertained to be duly safe in front; and that immediately on the passage of the train they go up again, and, by remaining up, keep the road closed against any engine or train whose approach has not been duly announced in advance, so as to be known at the first and second cabins in front of it and kept closed, unless the entire block section between those two cabins is known to have been left clear by the last preceding engine or train having quitted it, and is sufficiently presumed not to have met with any other obstruction, by shunting of carriages or wagons, or by accident, or in any other way.

This new arrangement, which appears to be a very important improvement, has already been brought into action with success on several sections of the Caledonian Railway; and it is being extended as rapidly as possible on the lines of the Caledonian Company, where the ordinary mode of working the block system has hitherto been adopted.

The mechanisms and arrangements I have now briefly mentioned are only a portion of the numerous contrivances in use for abatement of danger in railway traffic. It is to be understood that by no mechanisms whatever can perfect immunity from accidents be expected. The mechanisms are liable to break or to go wrong. They must be worked by men, and the men are liable to make mistakes or failures. We shall continue to have accidents; but if we cannot do away with every danger, that is no reason why we should not abate as many dangers as we can.

Within the past twenty years very remarkable progress has been made in steam navigation generally, and more especially, I would say, in oceanic steam navigation. In this we meet with the realisation of great practical results from the combination of improved mechanical appliances and of physical processes depending on a more advanced knowledge of thermodynamic science.

The progress in oceanic steam navigation is due mainly to the introduction jointly of the screw propeller, the compound engine, steam-jacketing of the cylinders, superheated steam, and the surface-condenser.

The screw propeller, in its original struggle for existence, when it came into competition with its more fully developed rival, the paddle-wheel, met with favouring circumstances in the want—then strongly felt—of means suitable for giving a small auxiliary steam-power to ships arranged for being chiefly propelled by sails. For the accomplishment of this end the paddle-wheel was ill-suited; and so the screw propeller got a good beginning for use on long oceanic voyages, Afterwards, in the course of years, there followed a long series of new inventions and improved designs in the adaptation of the steam-engine for working advantageously with the new propeller; and it has resulted that now, instead of the screw being used as an auxiliary to the sails, the sails are more commonly provided as auxiliaries to the screw. For long oceanic voyages it became very important or essential to get better economy in the consumption of fuel. In order to economise fuel, high-pressure steam, with a high degree of expansion and with condensation, was necessary. This led to the practical adaptation, for the propulsion of vessels, of the compound engine,—an old invention, which originated with Hornblower in the latter part of the last century, and was afterwards further developed by Wolff. The high degrees of expansion could not be advantageously used in cylinders heated only by the ordinary supply of steam admitted to them for driving the piston; and more especially when that steam was boiled off directly from water without the introduction of additional heat to it after its evaporation. The knowledge of this, which was derived through important advances made in thermo-dynamic science, led to the introduction into ordinary use in steam navigation of steam-jacketed cylinders, and to the ordinary use also of superheated steam. With increased efforts towards economy of space in the hold of the ship, which became the more essential when very long voyages were to be undertaken, and with the new requirement of greatly increased pressure in the steam, the old marine boilers, with their flues of riveted plates, were superseded by tubular boilers more compact in their dimensions and better adapted for resisting the high pressure of the steam. In connection with these various changes, the old difficulty of the growth of stony incrustations in the boilers became aggravated rather than in any way diminished. As the only available remedy for this, there ensued the practical development and the very general introduction of the previously known, but scarcely at all used, principle of surface condensation instead of condensation by injection. A supply of distilled water from the condenser is thus maintained for feeding the boilers, and incrustations are avoided. The consumption of coal is often found now to be reduced to about 2 lbs. per indicated horse-power per hour, from having been 4 or 5 lbs. in good engines in times previous to about twenty years ago.

Before the times of ocean telegraph-cables very little had been done in deep-sea sounding; but when the laying of ocean cables came first to be contemplated, and when it came afterwards to be realised, the obtaining of numerous soundings became a matter of essential practical importance. In the ordinary practice of deep-sea sounding, as carried on both before and since the times of ocean telegraph-cables, until a a year or two ago, a hempen rope or cord was used as the sounding-line, and a very heavy sinker—usually weighing from 2 to 4 cwts.—was required to draw down the hempen line with sufficient speed, because the frictional resistance of the water to that large and rough line moving at any suitable speed was very great. The sinker could not be brought up again from great depths; and arrangements were provided, by means of a kind of trigger-apparatus, so that when the bottom was reached the sinker was detached from the line, and was left lying lost on the bottom, the line being drawn up without the sinker, but with only a tube of no great weight, adapted for receiving and carrying away a specimen of the bottom. For the operation of drawing up the hempen line with this tube attached, steam-power has been ordinarily used, and practically must be regarded as necessary.

A great improvement has, within the last two or three years, been devised and practically developed by Sir William Thomson. Instead of using a hempen sounding-line, or a cord of any kind, he uses a single steel wire of the kind manufactured as pianoforte wire. He has devised a new machine for letting down into the sea the wire with its sinker, and for bringing both the wire and the sinker up again when the bottom has been reached. With his apparatus, in its earliest arrangement, and before it had arrived at its present advanced condition of improvement, he sounded, in June, 1872, in the Bay of Biscay, in a depth of 2700 fathoms, or a little more than 3 miles, and brought up again his sinker of 30 lbs. weight after it had touched the bottom; and brought up, also, an abundant specimen of ooze from the bottom, in a suitably arranged tube attached at the lower end of the sinker.

An important feature in his machine consists in a friction-brake arrangement, by which an exactly adjusted resistance can be applied to the drum or pulley which holds the wire coiled round its circumference, and which, on being allowed to revolve, lets the wire run off it down into the sea. The resistance is adjusted so as to be always less than enough to bear up the weight of the lead or iron sinker, together with the weight of the suspending wire, and more than enough to bear up the weight of the wire alone. Thus it results that the arrival of the sinker at the bottom is indicated very exactly on board the ship by the sudden cessation of the revolving motion of the drum from which the wire was unrolling.

Another novel feature of great importance consists in the introduction of an additional hauling-up drum or pulley, arranged to act as an auxiliary to the main drum during the hauling-up process. The auxiliary drum has the wire passed once or twice round its circumference at the time of hauling up, and is turned by men so as to give to the wire extending from it into the sea most of the pull requisite for drawing it up out of the sea, and it passes the wire forward to the main drum, there to be rolled in coils relieved from the severe pull of the wire and sinker hanging in the water. Thus the main drum is saved from being crushed or crumpled by the excessive inward pressure which would result from two or three thousand coils of very tight wire, if that drum unaided were required to do the whole work of hauling up the wire and sinker.

The wire, though exposed to the sea-water, is preserved against rust by being kept constantly, when out of use, either immersed in or moistened with caustic soda. The fact that steel and iron may be preserved from rust by alkali is well known to chemists, and is considered to result from the effect of the alkali in in neutralising the carbonic acid contained in the water, as the carbonic acid appears to be the chief cause of the rusting of steel and iron.

This new method of sounding, depending on the use of pianoforte wire, was first publicly explained by Sir Wm. Thomson in the Mechanical Section of the British Association at the Brighton Meeting, two years ago; and in the interval which has since elapsed it has come rapidly into important practical use.

Electrical Science in English and Foreign Journals.

(In addition to our usual abstracts, there will be found under this heading the titles of papers on electrical science which have appeared in English and foreign journals from the commencement of the present century up to the date of the establishment of this journal).

Poggendorff's Annalen der Physik und Chemie.

Vol. XLV. (1838).

On Electric Retarding Force and Heating Power. M. Riess. P. 1.

On the Conductivity of Gold, Lead, and Tin, for Electricity, at Different Temperatures. M. Lenz. P. 105.

On the Induction Phenomena at Opening and Closure of a Voltaic Circuit. M. Jacobi. P. 132.

On the Galvanic Fly-Wheel. M. Knochenhauer. P. 149.

Researches on the Properties of the Magneto-Electric Currents. M. de la Rive. Pp. 163, 407.

On the Advantages of Long Multipliers, with some Observations on the Controversy of the Chemical and the Contact Theory of Galvanism. M. Fechner. P. 232.

On the Time for Development of an Electric Current. M. Jacobi. P. 281.

On some Magnetisation Phenomena. M. Poggendorff. P. 353.

Electric Polarisation of the Liquid as the Essence of all Galvanic Action of Circuits with Stiff and Liquid Conductors. M. Karsten. P. 438.

Vol. XLVI. (1839).

Eleventh Series of Experimental Researches on Electricity. Mr. Faraday. Pp. 1, 537.

On a New Magnet Electrometer. M. Neef. P. 104.

Observations on Electric Polarisation of Solid and Liquid Conductors. M. Schönbein. P. 109.

On a Remarkable Peculiarity of Electric Tension. M. Doppler. P. 128.

Unequal Heating of the Electrodes of a Voltaic Battery. Mr. Gassiot. P. 330.

On a New Condenser of Electricity. M. Peclet. P. 343.

On the Development of Static Electricity through Contact of Good Conductors. M. Peclet. P. 346.

Results of Three Years' Magnetic Observations at Marland, and Influence of the Moon on Magnetic Phenomena. M. Kreil. P. 443.

On the Electric Fluid in the Condition of Expansion in Vacuous Space. M. Masson. P. 487.

On the Oxidation of Platinum, and the Chemical Theory of the Voltaic Pile. M. de la Rive. P. 489.

Decomposition of Water by Thermo-Electricity. Mr. Watkins. P. 496.

Production of Heat by Thermo-Electricity. Mr. Watkins. P. 497.

Theory of Electric Telegraphy, with Description of a New Telegraph based on the Physiological Actions of Electricity. M. Vorsselman de Heer. P. 513.

On the Action of Electric Discharges on the Metals and Liquids through which they Occur. M. Henrici. P. 585.

On the Theory of Galvanism, with Reference to Observations of M. Pfaff on my Experiment of Alternating Polarity of a Galvanic Circuit with several Intermediate Plates in Pairs. M. Pohl. P. 595.

On the Thermal Action of Electric Currents. P. 674.

Vol. XLVII. (1839).

On the Electro-Chemical Peculiarities of Nitrate of Silver Solution. M. Fechner. P. 1.

Twelfth Series of Experimental Researches on Electricity. Mr. Faraday. Pp. 33, 271, 529.

Magnetisation and Production of Heat by a Current Excited through the Closing Wire of the Electric Battery. M. Riess. P. 55.

On Electro-Magnetism as a Motor Force. M. Vorsselman de Heer. P. 76.

New Observations on the Voltaic Polarisation of Solid and Liquid Conductors. M. Schönbein. P. 101.

On the Regularity in Chemical Action of the Voltaic Battery. P. 123.

Decomposition and Re-formation of Water by a Simple Platinum Battery. Mr. Grove. P. 132.

Magnetic Expedition to the Southern Hemisphere, and the Establishment of Magnetic Stations in East Indies, South Africa, St. Helena, Van Diemen's Land, and Canada, at Expense of the British Government. P. 215.

On the General Magnetic Relations and Characters of Metals. Mr. Faraday. P. 218.

On the Laws of Electro-Magnets. MM. Lenz and Jacobi. P. 225.

On the Attraction of Electro-Magnets. MM. Jacobi and Lenz. P. 401.

On a Change in the Electromotive Condition of the Surface of Zinc in Contact with Alkaline Liquids, under Joint Action of the Electric Current. M. Munck, of Rosenschöld. P. 418.

On the Chemical Actions of Weak Electric Currents with Long Duration. Mr. Bird. P. 430.

On the Electric Polarisation of Metals. M. Henrici. P. 431.

On the Properties of Bound Electricity. M. Knochenhauer. P. 444.

On Thermo-Electric Batteries. M. Muncke. P. 451.

On a Phenomenon observed in a Large Wollaston Battery. M. Lenz. P. 461.

On the Chemical Changes produced in Nitric Acid, Spirit of Wine, and Ether, under the Double Influence of the Voltaic Current and of Platinum. M. Schönbein. P. 563.

On some Points in the Doctrine of Galvanism. M. Lenz. P. 584.

On the Thermo-Electric Currents of Mercury. M. Matteucci. P. 600.

On the Thermo-Electric Action of Mercury. M. Vorsselman de Heer. P. 602.

Foliation of Clay through Electricity. Mr. Fox. P. 604.

Vol. XLVIII. (1839).

On the Becquerel Battery, and Production of Electricity through Contact of Liquids in General. M. Fechner. Pp. 1, 225.

On the Chemical and the Magnetic Galvanometer. M. Jacobi. P. 26.

On the Action of Bundles of Iron Wire at Opening of the Galvanic Circuit. M. Magnus. P. 95.

Thirteenth Series of Experimental Researches on Electricity. Mr. Faraday. Pp. 269, 424, 513.

Notice on Electric Currents in Veins of Ore. M. Reich. P. 287.

On the Thermal Action of Electric Discharges. M. Vorsselman de Heer. P. 292.

Voltaic Battery with Great Electromotive Force. Mr. Grove. P. 300.

On the Inability of Water to Conduct Voltaic Currents without being Decomposed. Mr. Grove. P. 305.

On M. Vorsselman de Heer's Development of my Heat Researches on the Electric Battery. M. Reiss. P. 320.

On the so-called Becquerel Battery. M. Henrici. P. 372.

On Lightning without Thunder. P. 378.

On the Properties of Magneto-Electric Currents. M. Lenz. P. 385.

Researches on the Production of Phosphorescence, and on Various Properties of the Electric Spark. M. Becquerel. P. 540.

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On Galvanic Batteries made with Two Liquids and Two Metals not in Contact. M. Poggendorff. P. 31.

On Induced Currents which, Galvanometrically Equal, have Unequal Physiological Action. M. Dove. P. 72.

On the Thermo-Electricity of Mercury. M. Vorsselman de Heer. Pp. 114, 119.

Voltaic Discharge. P. 122.

On the Delay of the Electric Discharge by means of Conductors standing near the Connecting Wires. M. Reiss. P. 393.

On the Phenomena of the so-called Charging Battery (*Ladungs Säule*), with Special Reference to the Voltaic Theory of the Galvanic Circuit. M. Pfaff. P. 461.

On the Thermo-Electricity of Crystals. M. Hankel. P. 493.

Note on a Voltaic Battery of Uncommon Strength. M. Schönbein. P. 511.

On some New Properties of the Electric Light with Reference to Production of Phosphorescence. M. Becquerel. P. 543.

On the Nature of the Radiation proceeding from Electric Sparks, and exciting Phosphorescence at a Distance. MM. Biot and Becquerel. P. 549.

Research on the Heat-Radiation of the Electric Spark. M. Becquerel. P. 574.

Note on a New Voltaic Battery. M. Schönbein. P. 589.

(To be continued).

Comptes Rendus Hebdomadaires des Séances de l'Academie des Sciences, Vol. lxxix., No. 3. July 20, 1874.

The Action of Two Current Elements.—M. J. Bertrand.—A purely mathematical paper.

Third Note on Electric Transmissions across Ligneous Bodies, included in the article on "*Electric Conductibility of Ligneous Bodies*," in the Telegraphic Journal for August 1, 1874.

Stratification of the Electric Light.—M. Neyreneuf.—We may obtain stratifications of the electric light under the following circumstances, admitting the production, with static electricity, of inversions of charges as rapid as those produced from the use of the Ruhmkorff coil:—Suppose the two condensers of the Holtz's machine joined together by a Geissler's tube instead of a continuous metallic conductor. Place the exciting body of the machine so as to only obtain small sparks, succeeding each other with great rapidity. Two inverse currents charge and discharge, then spread through the tube: well-defined stratifications may also be seen to appear.

No. 4. July 27, 1874.

Project for a Simplified Lightning Conductor.—M. E. Nouel.—The conclusions arrived at in the following lines were the results of observations made during a very violent storm that exhausted itself over Vendôme (Loir-et-Cher), in France, on 26th May last. The lightning on that occasion struck some telegraph-posts and three houses. M. Nouel found that in the case of the houses the lightning followed the sheet zinc roofing (without damage) to the spouts, and thence to earth. The author remarks that static electricity flows always to the surface of bodies, so that a gutter and its pipe, notwithstanding the thinness of the metal, constitute an excellent electric conductor, having less resistance than the best lightning-rods; that the thunder-bolt, as a rule, falls only during heavy showers, by taking advantage of the semi-communication with the earth offered by the vertical series of rain-drops. The summary of his conclusions are—(1). It is possible, almost without expense, to protect ordinary houses from lightning casualties, by establishing good metallic communication between the chimney-flues and roof, through the gutters, and by trusting to the rain to complete the communication to the ground. (2). That even for complete lightning-conductors we should utilise as a conductor the gutters and their pipings. (3). That there is need, in every case, to wholly replace the conductors of lightning-rods with hollow pipes of the same mass and of greater diameters. He decidedly rejects metallic cords, because electricity—always following the conductor's surface—only selects, or uses, from this cord a small number of its wires which may be easily volatilised.

No. 5. August 3, 1874.

The Thermic Effects of Magnetism.—M. A. Cazin.—Being detail of experiments conducted respecting the heat produced by magnetism in the core of an electro-magnet, and a description of fresh experiments to determine the *magnetic equivalent of heat.* The results of the experiments show that if we call m the quantity of temporary magnetism of the electro-magnet, l the polar distance, Q the number of calories created by the disappearance of this magnetism, A a coefficient constant for the same magnetising coil and the same circuit arrangement, then—

$$A\,Q = m^2 l$$

$$A = \frac{m^2 l}{Q}.$$

Were the magnetism only employed to produce heat the coefficient A would be constant, and would measure the number of *magnetic energy* units equivalent to one caloric. It would be the *magnetic equivalent of heat.* To find it, it is only necessary to measure Q and $m^2 l$ in absolute units.

Les Mondes. Vol. xxxiv., No. 14. August 6, 1874.

Contains nothing of interest on electrical subjects.

Bulletin of the Society for Encouragement of National Industry. Vol. i., 3rd Series, No. 8. August, 1874.

Report on M. d'Arlincourt's Autographic Telegraph.—M. Le Comte du Moncel.—In all autographic telegraphs, the succession of current being so exceedingly numerous and rapid, it became necessary, so as not to employ too energetic an electric source, accompanied with serious inconveniences, to work through the medium of electro-magnetic relays. The question how to obtain, by the medium of such an apparatus, the most rapid effects possible, for a long time occupied the attention of electricians, and seems, in the present instrument, to have been solved in a completely satisfactory manner. D'Arlincourt's relay, adopted by various telegraphic administrations, constitutes one of the most important parts of his apparatus. This relay is composed of an electro-magnet whose breech—that is to say, the cross-beam which unites the two arms—carries two iron appendages, between which oscillates the pallet or tongue-armature destined to complete local contacts. This is an opposite arrangement of ordinary electro-magnets, wherein the electro-magnetic action is accomplished by the medium of the free poles, whilst in this it is produced at the junctures of the magnetic cores with the crosspiece. The tongue-armature is itself polarised by contact with the pole of an energetic permanent magnet. Directly the current passes, the iron appendages become polarised with opposite polarity to those of the free ends, and these polarities tend to attract the pallet: the south pole of the pallet is attracted by the north pole of one iron appendage, whilst its north pole is repelled. But the pallet moves in the opposite direction, because the coils themselves exert a stronger magnetic influence. The tongue thus obeys the latter force so long as the current lasts. When the current ceases the influence of the coils instantaneously disappears; but it is otherwise with the soft iron cores, their residual magnetism being considerably increased by the extra current developed at the moment of opening the current. The little magnet (or tongue) therefore obeys the force of the iron appendage; and its residual magnetism, increased by the extra current, assists in breaking the local contact instead of—as in ordinary magnets—prolonging the contact. M. d'Arlincourt's apparatus belongs to the electro-chemical system; but it is of great simplicity, very sure in its effects, and the regulation of the synchronism is founded on a new and very ingenious plan. The motor-mechanism's movement is regulated not only by a vibrating plate, like in Hughes's apparatus, but by an additional plate forming a diapason with the first, and free in its movements. As in a diapason, the vibrations are isochronous; whatever may be their amplitude, they conduce to maintain the movement (which provokes them) within such limits; the time of oscillations remains the same, whether rectilinear or circular; and as the free stem compels that which is checked by the motor to vibrate in unison with itself, it maintains the regulating action, and plays in some fashion the part of a compensator. Moreover, at each turn of the receiving and transmitting cylinders, an arrest is mechanically produced, and the apparatus is so arranged that they cannot re-move until they are in a perfectly identical position. The movement of the motor is not, however, stopped.

Bulletin du Musée de l'Industrie de Belgique. June and July, 1874.

Possesses nothing of interest relating to electricity or magnetism.

Bulletino Telegrafico. Anno x. June, 1874.

This number contains a number of paragraphs relative to the administration of the Italian telegraphs, such as—On the female section of telegraph officials; on female institutions for instruction in telegraphy; heads of offices punished for breaches of regulations; precautions for preserving telegraph offices from the disturbing influences of atmospheric electricity; condition of the lines; the use of chestnut wood as least affected by atmospheric variations; lightning-conductors for telegraph-posts; commencement of the use of Hughes's apparatus on the Vienna and Venice line; interruption of a submarine cable under the Straits of Messina; opening of new telegraph offices, royal and private; and removals and promotions of officials. The non-official portion contains—A notice of telegraphic legislation in France; an account of a visit to the central telegraphic station at Florence. It appears that of the foreign telegrams despatched 45 per cent are for France, 14 for Britain, 12 for Germany, 10 for Austria and Hungary, 6 for Russia, 5 for Switzerland, 2 for America, and 6 for other States not specified.

The Meteorograph.—This instrument, invented by Prof. Theorell, of Upsal, if set in action by an electro-magnetic apparatus, observes and registers, without supervision, the readings of the barometer and thermometer, the moisture of the atmosphere, and the direction and pressure of the wind.

Electric Locomotion.—Experiments have been lately made, with the best results, on Lake Tegel, near Berlin, on electro-magnetic currents. It was found possible to guide a vessel at will by means of currents directed over the helm. This new process may be applied to torpedo boats, which will then not require any crew.

Revista de Telegrafos. Num. 14, Anno xiv.
July 15, 1874.

In addition to official news, this number contains the conclusion of an article on a new system of optical telegraphy, by the inventor, J. M. Aguinaga, depending on the electric light. The author discusses the various objections taken to his project, and gives instructions for manipulating and for receiving messages.

Animal Meteorologists.—In this paper attention is drawn to the forecasts of the weather afforded by certain animals, especially the leech and the frog. It is said that a leech, placed in a bottle of water, remains at the bottom, coiled up and motionless, if the weather is fine and the barometric pressure high. If rain may be expected during the day—which corresponds in general to a diminished pressure of the air—the leech rises to the surface of the water, and remains there until fine weather. If wind is approaching the leech darts about with great velocity. If a tempest is to be expected it remains out of the water, and experiences a kind of convulsions and violent agitations. In snow and prolonged rain the leech fixes itself at the orifice of the bottle. In permanent frost it remains at the bottom. On the contrary, a frog descends to the bottom before rain, and rises to announce fine weather.

City and Commercial Notes.

A DIVIDEND at the rate of 15½ per cent per annum was declared on the 18th ult. at the meeting of the Submarine Telegraph Company. The total receipts compare favourably with those of any corresponding half-year, with the exception of 1873, when they were unusually large.

Advices have been received that the *Great Eastern* steamship, with the new Anglo-American Cable on board, arrived at Heart's Content, Newfoundland, on Sunday morning, "all well," having experienced stormy weather during the entire voyage.

Reuter's Telegram Company, Limited, announce that, on and after the 1st September, they will undertake the transmission of telegrams of one word and upwards, at reduced rates, to the United States and Canada.

TELEGRAPH SHARE LIST.

Amount per Share.	NAME OF COMPANY.	Amount paid up.	Closing Quotations.
£		£	Aug. 31.
Stock	Anglo-American (Limited)	100	74½—75
10	Brazilian Submarine..	All	7¼—7½
10	Cuba	All	5⅞—6⅛
10	Direct Spanish	9	..—..
20	Direct United States Cable	All	13—13½
10	Eastern (Limited)	All	8—8¼
..	Do., New	..	104—106
10	Eastern Extn. Australia and China	All	7¾—8
10	Globe Telegraph and Trust	All	6⅝—6⅞
10	Do., 6 per cent Pref...	All	9⅞—10⅛
10	Great Northern	All	11—11½
25	Indo-European	All	16—16½
10	Mediterranean Extension (Limited)	All	4—4½
10	Do., 8 per cent Pref...	All	10¼—11¾
10	Panama and South Pacific	2½	..—..
8	Reuter's..	All	10½—11
Stock	Submarine	100	205—215
1	Do., Scrip	All	1⅞—2⅛
10	West India and Panama	All	4—4½
10	Do., 10 per cent Pref.	All	10⅜—10⅝
20	Western and Brazilian (Limited) ..	All	11—11½
1000 dls.	West Un. U.S. 7 per cent 1st M.B.	All	103—105
10	Hooper's Telegraph Works	All	12½—12¾
50	India-Rubber and Gutta Percha ..	All	19—22
Cert.	Submarine Cables Trust	100	104—107
12	Telegraph Construction	All	27½—28
100	Ditto Ditto 7 per cent Bonds	All	103—105

At the meeting on the 19th ult. of the Mediterranean Extension Telegraph Company, Limited, a dividend at the rate of 3 per cent per annum on the Ordinary Shares, as well as the usual dividend on the Eight Per Cent Preference Stock, was declared, leaving £500 to be carried to the reserve fund.

Patents.

ABRIDGMENTS OF PROVISIONAL AND COMPLETE SPECIFICATIONS.

54. W. R. B. Chamberlin, Captain in the 24th Regiment of Foot. *A new electromotive power.* Dated January 5, 1874.—Whereby the direct power of each magnet is used, and the alternate transmission and suspension of the current is directed and regulated by clockwork.

75. S. W. Wilson, of Philadelphia, now of Lombard Street, London, civil engineer. *Improvements in electrical-brake apparatus for railway purposes.* Dated January 6, 1874.—My said invention relates to improvements in portions of the electrical apparatus for operating railway brakes described in the Specification of Letters Patent bearing date the 13th December, 1870, No. 3266. An important part of the said apparatus is a contrivance for putting on and releasing the brakes, and which consists chiefly of a friction-plate provided with electro-magnets in connection with a battery and an armature plate. According to my present invention I modify the above apparatus, and provide a more efficient and economical electric clutch.

94. W. E. Newton, of Middlesex, civil engineer. A communication from J. B. Stone, of Boonton, New Jersey, U.S. *Improvements in electro-magnets, and in the application of the same for obtaining motive power.* Dated January 7, 1874.—The invention consists of a combination of fixed and movable magnets, constructed with channels or corrugations on their faces in courses parallel to the direction of motion, and in a construction and arrangement of parts whereby the continuous fixed and movable magnets—when magnetic and attracting each other consecutively—are made to resemble, as regards their action, V-shaped magnets with the opposite poles attracting each other, and with the one pole fixed and the other movable.

124. E. T. Truman, of Middlesex. *Improvements in the manufacture of insulated telegraphic conductors, and in machinery for their manufacture and for the preparation of the materials therefor, parts of which machinery are applicable to other purposes.* Dated January 9, 1874.—This provisional specification refers to a former patent, No. 482, of 1872, for a process and machinery for covering wire with insulating material, and describes means of imparting rotation to the wire without giving any rotation to the receiving drum except the ordinary axial rotation. The provisional specification also describes a mode of and apparatus for forming a perfectly solid covering to those portions of the wire which form the union between the various lengths in which the covered wire is necessarily made. It also describes the employment in the machines usually termed covering-machines of two screws, one in a hopper, and the other in a casing which is supplied by the hopper. The combined action of the two screws causes the material to issue regularly and uniformly by the outlet of the casing, which may communicate with a tube or die, through which the wire to be covered travels. It also describes means of entirely or partially closing, at will, all or some of the openings in the cylinders of machines for washing and cleansing gutta-percha and other analogous materials, the object being to render the escape of material in the raw state or in small pieces, and before agglomeration has taken

place (which is the case with existing machines), impossible.

168. C. D. Abel, of Middlesex. A communication from F. A. E. Redslob, of Robertsau, in Alsace Lorraine. *Improvements in electric tell-tales for pressure-gauges.* Dated January 13, 1874.—This invention relates to an electric tell-tale, whereby—when the index of a pressure-gauge attains a predetermined point—an electric bell at a distance is caused to sound, by bringing into contact two springs in the electric circuit of a battery and the bell. The springs are mounted on an adjustable framing, so that they can be set for contact to be made when the index of the gauge reaches any desired point in its dial. The bell apparatus may be of any known construction, but is preferably made to consist of an electro-magnet composed of wires within a coil, bent back so as to present three branches, provided with an armature composed of a number of thin iron plates secured to a vibrating plate which works the bell-hammer, and on which is a contact plate that can be shifted so as to present a fresh contact surface.

253. A. M. Clark, of Middlesex, patent agent. A communication from W. E. Sawyer, of Washington, Columbia, U.S. *Improvements in electric telegraph apparatus, and in alphabetical symbols for use in transmitting telegraphic messages.* Dated January 20, 1874.—The invention relates to the use, with a galvanometer needle, of a crosspiece with eye, by which a ray of light is transmitted on to a moving photographically-sensitised tape of paper, so as to record the movements of the needle thereon by connected or disconnected angular lines or symbols, a set of which forms an alphabet that is more easily read and occupies less space than those heretofore employed.

256. J. B. Stearns, of Boston, Massachusetts, U.S., now of London, electrician. Partly a communication from J. C. Upham, of Sydney, Cape Breton, Nova Scotia. *Improvements in electric telegraph apparatus.* Dated January 21, 1874.—This invention relates to telegraphic apparatus whereby two different messages may be transmitted at the same time in one direction upon a single wire, and either one message or two different messages may be transmitted in the opposite direction at the same time upon the said wire,—that is to say, two, three, or four messages may be sent at the same time through a single wire or cable.

270. W. T. Whiteman, of Middlesex, gentleman. *Improvements in and apparatus for signalling on railways.* Dated January 22, 1874.—This invention consists in giving signals automatically, on or to trains, by means of electrical apparatus carried by such trains acting in conjunction with other electrical apparatus set on the permanent way.

293. T. Walker, of Middlesex. *Improvements in the means of transmitting electric currents for telegraphic and other purposes.* Dated January 23, 1874.—This invention relates to means of rendering an uninsulated or partially insulated wire available for the transmission of electric currents, and to the partial insulation and protection by inexpensive materials of wires so employed. Between the receiving instruments and the end of the wire next to it is interposed a battery, preferably of iron, to which the wire is connected with a less oxidisable metal, to which the instrument is connected. The wire is then capable of transmitting electric currents sent into it at its distant end, notwithstanding its defective insulation. To form an insulating and protecting covering for such wires, compounds of lac, rosin, tar, oil, are applied either as a paint or in more solid condition, by means of a die, and tape or fibre served with such compounds to give adhesion.

UNITED STATES.

151,568. C. Clamond, Paris, France. *Thermo-electric pile.* Dated May 22, 1874.—1. The mode of uniting the negative strip with the bar by means of a metallic ring or bent, soldered to or making part of the strip, and incorporated into the body of the bar by casting. 2. The manufacture of the bars of thermo-electric piles, by casting the same in moulds preliminarily heated to near the fusing-point of the thermo-electric material. 3. The combination, with the elements A, of the central perforated radiating cylinder B, made of refractory material, the pipe E, and the Bunsen burner *e*, the same being arranged and operating together.

152,031. W. C. Baker, New York. *Electrical temperature regulator.* Dated March 27, 1874.—Temperature raised too high causes the thermostat to close circuit to a magnet, shutting off warm air and admitting cool air. The combination of a thermostat circuit-closer and an electro-magnet with a damper and heated and cold air pipes.

152,199. R. W. Walker, Oxford, N.Y. *Telegraph key.* Dated April 25, 1874.—The improved telegraph key for transmitting despatches simultaneously over several lines, composed of insulated plates, as many as there are lines to be connected, which are provided with sidewise projecting front and rear lugs, or extensions, for attaching the contact-screws and connecting wires.

152,281. P. B. Delaney, Washington, D.C. *Telegraph relay.* Dated November 28, 1873.—Armature at each end of magnets having retractile springs of different tensions. One armature sometimes directly in main line circuit, so as to completely break such circuit, giving notice that line is in use, even in "leaky" weather. 1. A relay having two armatures and two armature levers, capable of different adjustments. 2. In combination with a relay magnet having two armatures, the additional magnet. 3. In combination with a telegraphic circuit, an armature and its stops, arranged to momentarily break such circuit on the movement of the armature between its stops. 4. In combination with a relay having two armatures, one or more sounders, the circuits of which are closed by the movement of either armature of the relay.

152,356. T. M. Foote and C. A. Randall, Brooklyn, N.Y. *Telegraph key.* Dated March 20, 1873.—Depression of key lever closes circuit from one pole; elevation reverses circuit. 1. The combination, with the rocking lever of a key provided with screws, as described, of springs upon which the screws make a sliding contact when the lever is raised or depressed. 2. The screws in a key in combination with a battery, and with circuit connections thereto, the alternate raising and depressing the lever of said key, causing alternate positive and negative currents to be sent over the main circuit.

To Correspondents.

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